PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 20 June 2001 (20.06.01)	
International application No. PCT/KR00/00935	**Applicant's or agent's file reference** P00P7005/PCT
International filing date (day/month/year) 21 August 2000 (21.08.00)	**Priority date** (day/month/year) 30 September 1999 (30.09.99)
Applicant KIM, Bong-Cheol	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

06 April 2001 (06.04.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Olivia TEFY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below
P00P7005/PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/KR00/00935	21 AUGUST 2000 (21.08.2000)	30 SEPTEMBER 1999 (30.09.1999)
Applicant		
PROWTECH INC. et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
   ☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:
   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ the statement that the subsequenlty furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (See Box II).

4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawing** to be published with the abstract is Figure No. 3
   ☒ as suggested by the applicant.
   ☐ None of the figures.
   ☐ because the applicant failed to suggest a figure.
   ☐ because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR00/00935

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 C30B 23/02, H01L 21/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC C30B 23/02, H01L 21/20, H01L 21/82

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and Applications for Inventions since 1975
Korean Utility Models and Applications for Utility Models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

NPS, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3-22410 A (NIPPON TELEGR & TELEPH CORP.) 30 January 1991 see the whole document	1-12
Y	JP 61-179523 A (AGENCY OF IND SCIENCE & TECHNOL.) 12 August 1986 see the whole document	1-12
A	KR 92-7232 A (MOTOROLA INC.) 28 April 1992 see the whole document	1-12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevence

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 DECEMBER 2000 (05.12.2000)	05 DECEMBER 2000 (05.12.2000)

Name and mailing address of the ISA/KR	Authorized officer
Korean Industrial Property Office Government Complex-Taejon, Dunsan-dong, So-ku, Taejon Metropolitan City 302-701, Republic of Korea	BAHN, Yong Byung
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5566

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR00/00935

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 3-22410 A	20.01.91	none	
JP 61-179523 A	12.08.86	none	
KR 92-7232 A	28.04.92	DE 69129828 CO	27.08.98
		DE 69129828 T2	04.03.99
		EP 477683 A2	01.04.92
		EP 477683 A3	05.05.93
		JP 4262570 A2	17.09.92
		US 5154946 A	13.10.92

PCT REQUEST

P00P7005/PCT

Original (for **SUBMISSION**) - printed on 21.08.2000 01:31:17 PM

0	**For receiving Office use only**	
0-1	International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.91 (updated 01.07.2000)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Korean Industrial Property Office (RO/KR)
0-7	Applicant's or agent's file reference	P00P7005/PCT
I	Title of invention	APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM
II	Applicant	
II-1	This person is:	applicant only
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II-9	Facsimile No.	82-043-534-1894
II-10	e-mail	jhson@prowtech.com

PCT REQUEST P00P7005/PCT

Original (for **SUBMISSION**) - printed on 21.08.2000 01:31:17 PM

III-1	**Applicant and/or inventor**	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
III-1-4	Name (LAST, First)	KIM, Bong-Cheol
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III-1-6	State of nationality	KR
III-1-7	State of residence	KR
IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	CHOI, Jong-Sik
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IV-1-4	Facsimile No.	82-2-553-1450
IV-1-5	e-mail	sspat@shinsung-patent.co.kr
IV-2	Additional agent(s)	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	WONN, Seok-Hee
V	**Designation of States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT

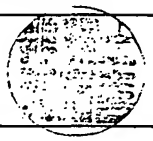
PCT REQUEST P00P7005/PCT

Original (for **SUBMISSION**) - printed on 21.08.2000 01:31:17 PM

V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW	
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.		
V-6	**Exclusion(s) from precautionary designations**	NONE	
VI-1	**Priority claim of earlier national application**		
VI-1-1	Filing date	30 September 1999 (30.09.1999)	
VI-1-2	Number	1999-41892	
VI-1-3	Country	KR	
VII-1	**International Searching Authority Chosen**	Korean Industrial Property Office (KIPO) (ISA/KR)	
VIII	**Check list**	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	7	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	p00p7005pct.txt
VIII-5	Drawings	3	-
VIII-7	TOTAL	18	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-9	Separate signed power of attorney	✓	-
VIII-12	Priority document(s)	Item(s) VI-1	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-18	**Figure of the drawings which should accompany the abstract**	3	
VIII-19	**Language of filing of the international application**	English	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name (LAST, First)	CHOI, Jong-Sik	

PCT REQUEST P00P7005/PCT

Original (for **SUBMISSION**) - printed on 21.08.2000 01:31:17 PM

IX-2	**Signature of applicant or agent**	
IX-2-1	Name (LAST, First)	WONN, Seok-Hee

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/KR
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

(12) INTERNATIONAL [redacted]ICATION PUBLISHED UNDER THE PAT[redacted]COOPERATION TREATY (PCT)

(19) World Intellectual Pr perty Organization
International Bureau

(43) International Publication Date
5 April 2001 (05.04.2001)

PCT

(10) International Publication Number
WO 01/23648 A1

(51) International Patent Classification[7]: C30B 23/02, H01L 21/20

(21) International Application Number: PCT/KR00/00935

(22) International Filing Date: 21 August 2000 (21.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1999/41892 30 September 1999 (30.09.1999) KR

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(74) Agents: CHOI, Jong-Sik et al.; Haecheon Bldg., 741-40, Yeoksam 1-dong, Kangnam-ku, Seoul 135-081 (KR).

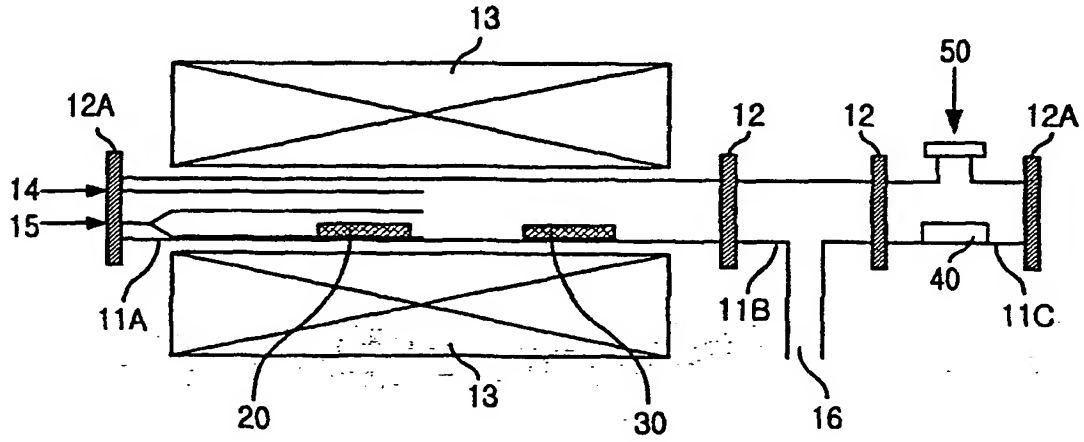
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM



(57) Abstract: The present invention relates to an apparatus and a method for forming a single crystalline nitride substrate, and more particularly, to an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate. A method for forming a compound semiconductor substrate includes the steps of: a) preparing a parent substrate; b) forming a single crystalline film on the parent substrate in a reacting chamber; c) maintaining the single crystalline film in a predetermined temperature which is higher than a room temperature; and d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate. Accordingly, the present invention provides a large single crystalline nitride substrate, by preventing cracks caused by the lattice mismatch with the parent substrate.

WO 01/23648 A1

APPARATUS AND METHOD FOR FORMING SINGLE CRYSTALLINE NITRIDE SUBSTRATE USING HYDRIDE VAPOR PHASE EPITAXY AND LASER BEAM

Description

Technical Field

The present invention relates to an apparatus and a method for making a single crystalline nitride substrate; and, more particularly, to an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate.

Background Art

A GaN single crystalline substrate, as an example of a single crystalline nitride substrate, will be described. Generally, the GaN materials has a melting point more than of 2400 ℃ and the dissociation pressure of nitride in the GaN materials is about ten thousand atm. Accordingly, this high melting point and high dissociation pressure make it impossible to create a large single crystalline GaN bulk using typical growing methods of the semiconductor crystals. A needle-shaped crystal growing method, in which a gallium gas directly reacts on an ammonia gas at a high temperature of about 1000 ℃ to 1150 ℃, and a plate-shaped crystal growing method, in which nitrogen is dissolved in liquid gallium at a high temperature of about 1500 ℃ to 1600 ℃ and at a high nitrogen pressure corresponding to about 20000 atm, has been used to create a single crystalline GaN bulk (hereinafter, referred to as a GaN bulk).

However, these crystal growth methods have made a small-sized GaN bulk which has only a few millimeters in size and about 100 μm in thickness. Accordingly, it is impossible to achieve a commercial success in using the GaN bulk.

To solve the above problem, a hydride vapor phase

epitaxy has been used to create the GaN bulk at a growing rate of 100 μm/hour. That is, after forming a thick GaN film on a parent substrate, such as sapphire or SiC substrate, the parent substrate is removed and then the GaN bulk is finally formed.

The removal of the parent substrate is carried out by the mechanical polishing method or laser beam. In particular to laser, as shown in Fig. 1, after forming the thick GaN film on the parent substrate at a high temperature of about 1000 ℃ to 1100 ℃, the thick GaN film on the parent substrate is cooled down to a room temperature. After increasing the temperature of the parent substrate up to about 600 ℃, the thick GaN film is separated from the parent substrate using laser beam in an additional apparatus different from the hydride vapor phase epitaxy ("Large free-standing GaN substrate by hydride vapor phase epitaxy and laser induced lift-off," by K. Kelly et al, Jpn. J. Appl. Phys. Vol. 38, No. 3A (pt 2), 1999).

In the above-mentioned hydride vapor phase epitaxy, since the thick GaN film is formed on the sapphire substrate at a high temperature and it is cooled down to the room temperature, cracks are generated by the lattice mismatch and thermal expansion coefficients between the GaN film and the sapphire substrate. Because of these cracks, the GaN bulk is restricted within a small-sized substrate and electric characteristics therein are also deteriorated.

Disclosure of Invention

It is, therefore, an object of the present invention to provide an apparatus and a method for preventing cracks from being generated in a single crystalline nitride substrate which is made by a hydride vapor phase epitaxy method.

Another object of the present invention is to provide an apparatus and a method for forming a large single crystalline nitride substrate on a commercial basis.

In accordance with an aspect of the present invention, there is provided an apparatus for forming a compound semiconductor substrate, the apparatus comprising: a reacting chamber for forming a single crystalline film on a parent substrate; a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline film is separated from the parent substrate at a higher temperature than a room temperature; and a supporter for supporting the single crystalline film and the parent substrate and maintaining the single crystalline film in a predetermined temperature.

In accordance with another aspect of the present invention, there is provided a method for forming a compound semiconductor substrate, the method comprising the steps of: a) preparing a parent substrate; b) forming a single crystalline film on the parent substrate in a reacting chamber; c) maintaining the single crystalline film in a predetermined temperature which is higher than a room temperature; and d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate.

According to the present invention, a thick GaN film is formed on a parent substrate, such as sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC), which has the lattice mismatch with the single crystalline GaN film and a different thermal expansion coefficient, and the parent substrate is heated up to a range of 600 ℃ to 1000 ℃. In this temperature range, the single crystalline GaN film is separated from the parent substrate by laser beam.

Brief Description of Drawings

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a plot illustrating a temperature variation

in a conventional method for forming a single crystalline nitride substrate;

Fig. 2 is a plot illustrating a temperature variation in a method for forming a single crystalline nitride substrate according to the present invention;

Fig. 3 is a schematic cross-sectional view of an apparatus for forming a single crystalline nitride substrate according to the present invention; and

Figs. 4A to 4D are schematic cross-sectional views illustrating a method for forming a single crystalline nitride substrate according to the present invention.

Best Mode for Carrying out the Invention

Referring to Fig. 3, a horizontality-type hydride vapor phase epitaxy apparatus of an atmospheric pressure is shown in order to form a single crystalline nitride substrate. The hydride vapor phase epitaxy apparatus includes a reacting chamber 11A in which a quartz boat (not shown) is placed, a heating chamber 11C having a supporter 40 to maintain a specimen, and an exhausting chamber 11B positioned between the reacting chamber 11A and the heating chamber 11C and coupled to an exhausting system 16. The temperature of the supporter 40 in the heating chamber 11C is maintained in a specific temperature range and laser beam illumination to separate a single crystalline nitride film from a parent substrate 30 is carried out in the heating chamber 11C. Further, each of the chambers 11A to 11C adjacent to the exhausting chamber 11B is sealed up with shutters 12 and flanges 12A are mounted on both ends of the chambers 11A and 11C.

The reacting chamber 11A is surrounded by a multi-step electric furnace 13 and is connected to a first inlet to supply an ammonia gas and a second inlet to supply hydrochloric acid and nitrogen gases. These gases react on Ga materials 20 within the reacting chamber 11A and then a thick GaN film is deposited on the parent substrate 30 adjacent to the Ga materials 20. While the thick GaN film is grown in the reacting chamber 11A, the reacting gases are

purged away through the exhausting system 16 in the exhausting chamber 11B and when the growth of the single crystalline nitride substrate (the thick GaN film) has been finished, the reacting chamber 11A is isolated from the exhausting chamber 11B by the shatter 12. The parent substrate 30 on which the thick GaN film is formed is removed onto the supporter 40 in the heating chamber 11C without being exposing to air and laser beam is illuminated on the backside of the parent substrate 30 at a temperature of about 600 ℃ to 1000 ℃ to separate a single crystalline GaN film (thick GaN film) from the parent substrate 30. It should be noted that the thick GaN film and the parent substrate 30 are not cooled down to a room temperature.

Although the exhausting chamber 11B, as shown in Fig. 3, is positioned between the reacting chamber 11A and the heating chamber 11C, the reacting chamber 11A may be adjacent to the heating chamber 11C and the exhausting system 16 may be directly connected to the reacting chamber 11A.

The hydride vapor phase epitaxy apparatus shown in Fig. 3 may be used to form group Ⅲ-N (nitrogen) compounds of single crystalline substrates, such as AlN, InN, GaInN, AlInN and AlGaInN, as well as the GaN single crystalline substrate, containers having Ga and In materials may be provided in the reacting chamber 11A and the hydrochloric acid and nitrogen gases flow into the reacting chamber 11A. Figs. 4A to 4D illustrate a method for forming the GaN single crystalline substrate.

First, referring to Fig. 4A, the parent substrate 30 selected from one of an oxide substrate, such as sapphire (Al_2O_3) or spinel ($MgAl_2O_4$), and a silicon carbide substrate, such as SiC, is prepared and generally these parent substrates may have the lattice mismatch with the GaN materials and a different thermal expansion coefficient.

Next, referring to Fig. 4B, the thick GaN film 31 is formed on the parent substrate 30 in the hydride vapor phase epitaxy apparatus, as shown in Fig. 3, having the quartz boat in its reacting chamber 11A and the supporter 40 in its

heating chamber 11C. The group III elements such as Ga are positioned at a region which is maintained at a temperature of about 600 ℃ to 900 ℃ by the multi-step electric furnace 13. At this time, the parent substrate is maintained at a temperature of about 1000 ℃ to 1100 ℃. The reacting chamber 11A in which the quartz boat is placed is pumped out up to about 10-3 torr, the reacting chamber 11A is gradually heated, and then the nitrogen gas injection into the reacting chamber 11A starts from about 600 ℃. When the reacting chamber 11A reaches to a temperature at which the thick GaN film is to be grown, the hydrochloric acid gas flows onto the Ga materials in the quartz boat and the ammonia gas is provided to the parent substrate 30 to form the thick GaN film 31 on the parent substrate 30 at a thickness of about 100 μm to 550 μm.

After forming the thick GaN film 31 on the parent substrate 30, the supply of the hydrochloric acid gas is broken off and the parent substrate 30 on which the thick GaN film 31 is formed is cooled with the supply of nitrogen and the ammonia gases until the temperature of the thick GaN film 31 reaches to a predetermined temperature range, e.g., about 600 ℃ to 1000 ℃.

Referring to Fig. 4C, when the temperature of the reacting chamber 11A reaches to 600 ℃ to 1000 ℃, the parent substrate 30 on which the thick GaN film 31 is formed is moved onto the supporter 40 in the heating chamber 11C. At this time, the temperature of supporter 40 is maintained at about 600 ℃ to 1000 ℃ and the bottom of the parent substrate 30 is turned over top so that the thick GaN film 31 is directly on the supporter 40. The turned upside of the parent substrate 30 is illuminated by laser beam. It should be noted that the thick GaN film 31 and the parent substrate 30 are not cooled down to a room-temperature.

Referring to Fig. 4D, the parent substrate 30 is separated from the thick GaN film 31 by the high power laser beam. Nd:YAG laser beam, which has wavelength of 355 nm, power of about 500 mJ, pulse period of 10 to 20 Hz and pulse width of 5 to 6 ns, may be used. When this high power laser

beam is illuminated on the parent substrate 30, the beam passes through the parent substrate 30 and is absorbed into the thick GaN film 31. If the thick GaN film 31 absorbs the high power laser beam, the GaN material, which is in a range of a few micrometers in thickness (dissolution area 32), are dissolved into gallium and nitrogen and the thick GaN film 31 is separated from the parent substrate 30 by this dissolution of the thick GaN film 31.

Since the single crystalline GaN substrate (the separated thick GaN film 31A has an uneven surface, the mechanical and chemical polishing using a diamond slurry is applied to the single crystalline GaN substrate 31A.

As apparent from the above, the present invention provides a high growing rate of the single crystalline nitride substrate without cracks caused by the lattice mismatch between other materials, by using the hydride vapor phase epitaxy method. Furthermore, the present invention provides stability and reliability of processing by effectively separating the single crystalline nitride substrate from the parent substrate by laser beam.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. An apparatus for forming a compound semiconductor substrate, the apparatus comprising:

a reacting chamber for forming a single crystalline film on a parent substrate;

a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline film is separated from the parent substrate at a higher temperature than a room temperature; and

a supporter for supporting the single crystalline film and the parent substrate and maintaining the single crystalline film in a predetermined temperature.

2. The apparatus as recited in claim 1, wherein the apparatus is a hydride vapor phase epitaxy apparatus.

3. The apparatus as recited in claim 1, wherein the single crystalline film is a nitride.

4. The apparatus as recited in claim 1, wherein the predetermined temperature is in a range of 600 ℃ to 1000 ℃.

5. The apparatus as recited in claim 1 or 2, wherein the apparatus further comprises an exhausting chamber positioned between the reacting chamber and the heating chamber, and wherein each of reacting, exhausting and heating chambers is isolated from each other by shutters.

6. A method for forming a compound semiconductor substrate, the method comprising the steps of:

a) preparing a parent substrate;

b) forming a single crystalline film on the parent substrate in a reacting chamber;

c) maintaining the single crystalline film in a predetermined temperature which is higher than a room

temperature; and

d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline film from the parent substrate.

7. The method as recited in claim 6, wherein the single crystalline film is a nitride.

8. The method as recited in claim 6, further comprising the steps of:

e) heating the parent substrate up to a predetermined temperature which is higher than a room temperature; and

f) moving onto a supporter the parent substrate on which the single crystalline film is formed, wherein the supporter is positioned in a heating chamber which is connected to the reacting chamber within a processing channel.

9. The method as recited in claim 6 to 8, wherein the parent substrate is selected from one of sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC) and the single crystalline film is a nitride.

10. The method as recited in claim 9, wherein the single crystalline film is formed by a hydride vapor phase epitaxy.

11. The method as recited in claim 9, wherein the step b) comprises the steps of:

a1) positioning a material selected from a group Ⅲ at a first temperature region of 600 ℃ to 900 ℃ in the reacting chamber and positioning the parent substrate at a second temperature region of 1000 ℃ to 1100 ℃ in the reacting chamber;

a2) injecting a nitrogen gas into the reacting chamber;

a3) injecting a hydrochloric acid gas into the reacting chamber; and

a4) injecting an ammonia gas into the reacting chamber.

12. The method as recited in claim 11, wherein the parent substrate is heated up to 600 ℃ to 1000 ℃.

FIG. 1

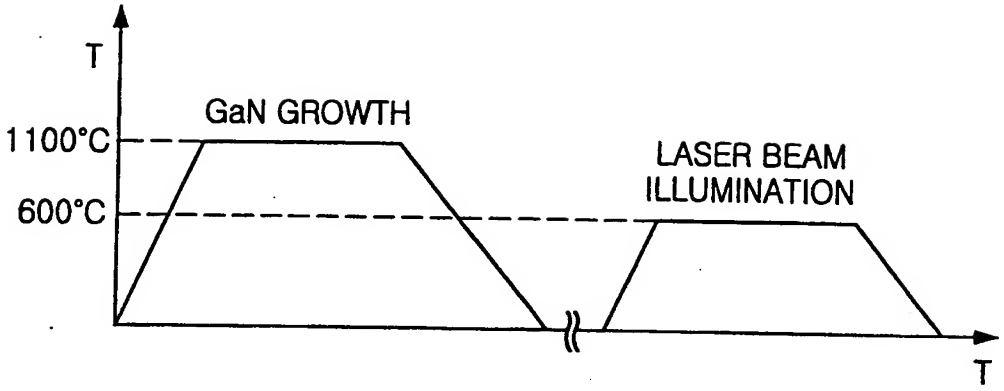

T
GaN GROWTH
1100°C
600°C
LASER BEAM
ILLUMINATION
T

FIG. 2

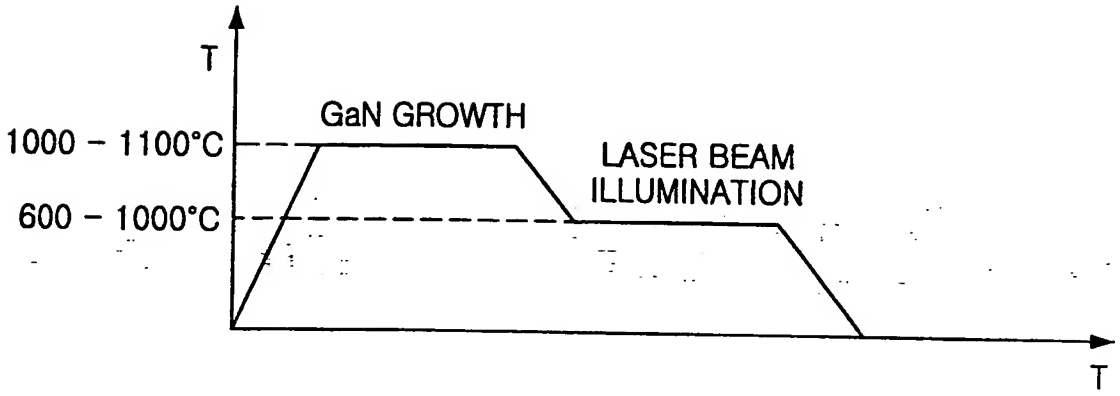

T
GaN GROWTH
1000 - 1100°C
600 - 1000°C
LASER BEAM
ILLUMINATION
T

FIG. 3

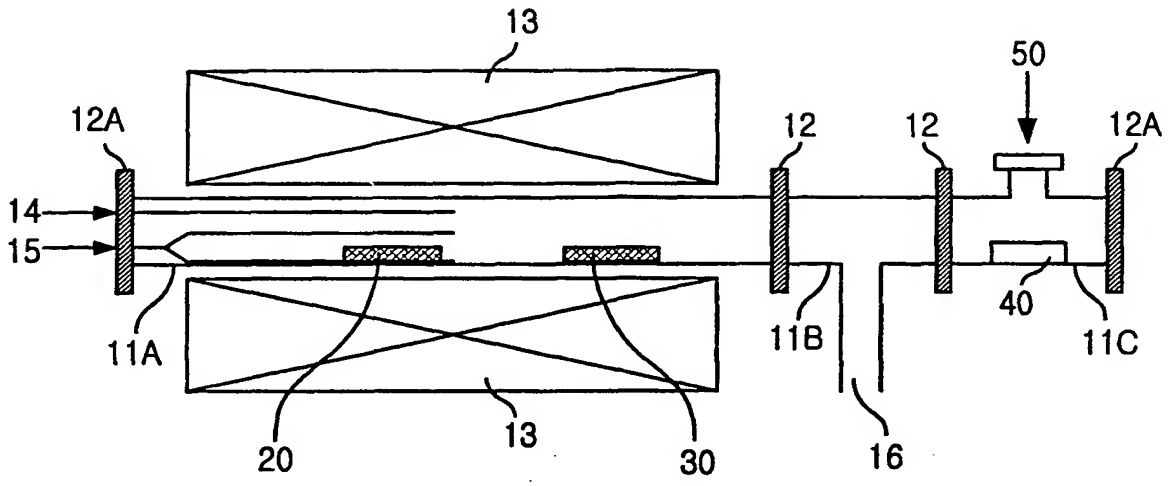


FIG. 4A

FIG. 4B

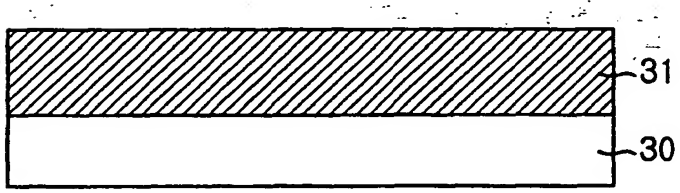


FIG. 4C

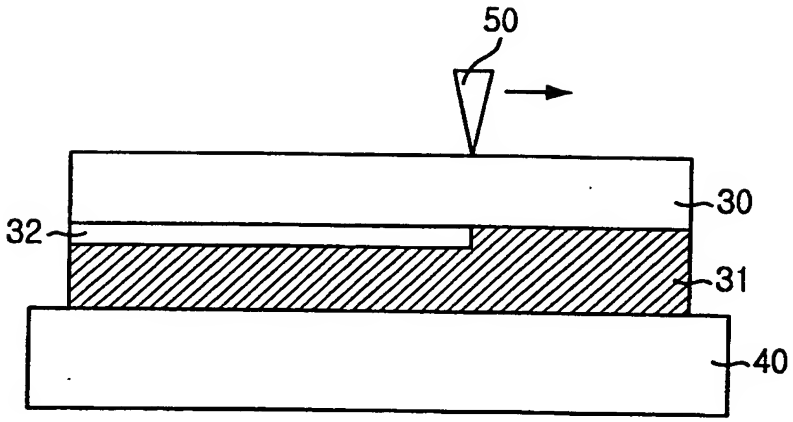
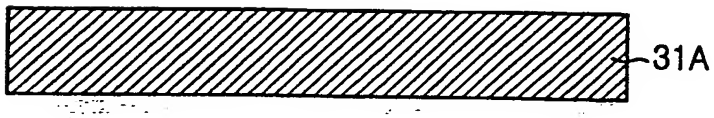


FIG. 4D



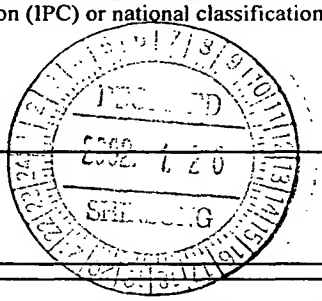
PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Artcle 36 and Rule 70)

Applicant's or agent's file reference P00P7005/PCT	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. **PCT/KR00/00935**	International filing date *(day/month/year)* 21 AUGUST 2000 (21.08.2000)	Priority date *(day/month/year)* 30 SEPTEMBER 1999 (30.09.1999)
International Patent Classification (IPC) or national classification and IPC **IPC7 C30B 23/02**		
Applicant PROWTECH INC. et al		



1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demamd	Date of completion of this report
06 APRIL 2001 (06.04.2001)	18 JANUARY 2002 (18.01.2002)
Name and mailing address of the IPEA/KR Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer SEONG, Young Hwan Telephone No. 82-42-481-5564

Form PCT/IPEA/409 (cover sheet) (July 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International aplication No.
PCT/KR00/00935

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1 - 7, 11 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☒ the claims:
pages _____ , as originally filed
pages _____ , as amended (together with any statment) under Article 19
pages _____ , filed with the demand
pages 8 - 10 , filed with the letter of 10/12/2001

☒ the drawings:
pages 1 - 3 , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

☐ the sequence listing part of the description:
pages _____ , as originally filed
pages _____ , filed with the demand
pages _____ , filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application(under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide** and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained inthe international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disc losure in the international applicationas as filed has been furinshed.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☐ the description, pages _____

☒ the claims, Nos. 3, 7

☐ the drawings, sheet _____

5. ☐ This opinion has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box(Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed." and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International aplication No.
PCT/KR00/00935

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1 - 10	YES
	Claims		NO
Inventive step (IS)	Claims	1 - 10	YES
	Claims		NO
Industrial applicability (IA)	Claims	1 - 10	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The following documents are referred to;
D1: JP 3-22410 A(30.01.91)
D2: JP 61-179523 A(12.08.86)
D3: KR 92-7232 A(28.04.92)

Novelty

None of the cited prior art describes an apparatus comprising a supporter for supporting the single crystalline nitride film and the parent substrate and an apparatus maintaining the single crystalline nitride film in a predetermined temperature ranging from 600℃ to 1000℃ for preventing cracks from being generated in a single crystalline nitrogen compound semiconductor substrate, which is made by a hydride vapor phase epitaxy method. Therefore claims 1-4 are new. A method for preparing a single crystalline nitrogen compound semiconductor substrate in the presense of the apparatus(claims 5-10) is novel because it uses the new apparatus for forming a nitrogen compound semiconductor substrate. Therefore claims 1-10 comply with Article 33(2) PCT.

Inventive Step

D1 refers to forming a semiconductor film having a fine pattern without using lithographic technique by growing a GaAs film while irradiating s substrate with an argon laser beam from outside of a vaccum container in a metal organic molecular beam epitaxial process.
D2 refers to forming a thin film of single crystal, having few defects due to heating, with a heater of energy beam irradiation, a lamp, etc., by using a silicon oxide nitride film as an insulation film between a thin film to be crystallized into a single crystal and a substrate.
D3 is a method of fabricating a CMOS structure that may be integrated into a BICMOS process flow, which includes forming N and P type doped wells in an isolation module.
No individual citation or obvious combination of D1, D2, D3 discloses an object and a constitution of the present invention to provide an apparatus and a method for preventing cracks from being generated in a single crystalline nitrogen compound semiconductor substrate, made by a hydride vapor phase epitaxy method. The single crystilline GaN film (corresponding to a single crystalline nitrogen compound semiconductor substrate) is formed on a parent substrate, such as sapphire (Al_2O_3), which has the lattice mismatch with the single crystilline GaN film, has a different thermal expansion coefficient, and has the parent substrate is heated up to a range of 600℃ to 1000℃. In this temperature range, the single crystalline GaN film is seperated from the parent substrate by raser-beam illumination.
Therefore the subject matters of claims 1 to 10 fulfil the requirement of Articles 33(3) PCT.

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of:

V. Reasoned statement under Article 35(2)

Industrial Applicability
The present invention relates to an apparatus and to a method for making a single crystalline nitrogen compound semiconductor substrate.
The present invention according to claims 1 to 10 is therefore fulfil the requirement of Article 33(4) PCT.

--------- NEW CITATIONS ---------
NONE

Claims

1(amended). An apparatus for forming a nitrogen compound semiconductor substrate, the apparatus comprising:

a reacting chamber for forming a single crystalline nitride film on a parent substrate;

a heating chamber connected to the reacting chamber within a processing channel, wherein the single crystalline nitride film is separated from the parent substrate by laser beam illumination at a higher temperature than a room temperature; and

a supporter for supporting the single crystalline nitride film and the parent substrate and maintaining the single crystalline nitride film in a predetermined temperature.

2. The apparatus as recited in claim 1, wherein the apparatus is a hydride vapor phase epitaxy apparatus.

3. The apparatus as recited in claim 1, wherein the predetermined temperature is in a range of 600 ℃ to 1000 ℃.

4. The apparatus as recited in claim 1 or 2, wherein the apparatus further comprises an exhausting chamber positioned between the reacting chamber and the heating chamber, and wherein each of reacting, exhausting and heating chambers is isolated from each other by shutters.

5(amended). A method for forming a nitrogen compound semiconductor substrate, the method comprising the steps of:

a) preparing a parent substrate;

b) forming a single crystalline nitride film on the parent substrate in a reacting chamber;

c) moving the parent substrate onto a heating chamber and maintaining the single crystalline nitride film in a

predetermined temperature which is higher than a room temperature; and

d) illuminating laser beam on a backside of the parent substrate and separating the single crystalline nitride film from the parent substrate.

6(amended). The method as recited in claim 5, further comprising the steps of:

e) heating the parent substrate up to a predetermined temperature which is higher than a room temperature; and

f) moving onto a supporter the parent substrate on which the single crystalline nitride film is formed, wherein the supporter is positioned in a heating chamber which is connected to the reacting chamber within a processing channel.

7(amended). The method as recited in claim 5 to 6, wherein the parent substrate is selected from one of sapphire (Al_2O_3), spinel ($MgAl_2O_4$) or silicon carbide (SiC).

8(amended). The method as recited in claim 7, wherein the single crystalline nitride film is formed by a hydride vapor phase epitaxy.

9. The method as recited in claim 7, wherein the step b) comprises the steps of:

a1) positioning a material selected from a group Ⅲ at a first temperature region of 600 ℃ to 900 ℃ in the reacting chamber and positioning the parent substrate at a second temperature region of 1000 ℃ to 1100 ℃ in the reacting chamber;

a2) injecting a nitrogen gas into the reacting chamber;

a3) injecting a hydrochloric acid gas into the reacting chamber; and

a4) injecting an ammonia gas into the reacting chamber.

10. The method as recited in claim 9, wherein the parent substrate is heated up to 600 ℃ to 1000 ℃.